Contents lists available at ScienceDirect

Drug and Alcohol Dependence

journal homepage: www.elsevier.com/locate/drugalcdep

Short communication

Adolescent treatment admissions for marijuana following recreational legalization in Colorado and Washington

Jeremy Mennis*, Gerald J. Stahler

Department of Geography and Urban Studies, Temple University, United States

ABSTRACT

Introduction: There is concern that recreational marijuana legalization (RML) may lead to increased cannabis use disorder (CUD) among youth due to increased marijuana use. This study investigates whether adolescent substance use disorder treatment admissions for marijuana use increased in Colorado and Washington following RML.

Methods: Annual data on 2008–2017 treatment admissions for marijuana use from the SAMHSA TEDS-A dataset for adolescents age 12–17 were used to model state treatment admissions trends. Difference-in-differences models were used to investigate whether treatment admissions increased following RML in Colorado/Washington compared to non-RML states, after adjusting for socioeconomic characteristics and treatment availability.

Results: Over all states in the analysis, the rate of adolescent treatment admissions for marijuana use declined significantly over the study period ($\beta = -3.375$, 95 % CI $= -4.842, -1.907$), with the mean rate falling nearly in half. The decline in admissions rate was greater in Colorado and Washington compared to non-RML states following RML, though this difference was not significant ($\beta = -7.671$, 95 % CI $= -38.798, 23.456$).

Conclusion: Adolescent treatment admissions for marijuana use did not increase in Colorado and Washington following RML. This may be because youth marijuana use did not increase, CUD did not increase (even if use did increase), or treatment seeking behaviors changed due to shifts in attitudes and perceptions of risk towards marijuana use.

1. Introduction

Cannabis use disorder (CUD) in adolescence is associated with mental health problems and other negative outcomes which can persist into adulthood (Kosty et al., 2016; Volkow et al., 2014). Because heavy marijuana use is a risk factor for CUD (Volkow et al., 2014), there is substantial concern that the growth of recreational marijuana legalization (RML) in the US and elsewhere will lead to a higher prevalence of CUD among youth due to increasing marijuana use (Hall and Lynskey, 2016). Though national survey data indicate that youth marijuana use generally has not increased over the past two decades (Miech et al., 2019), youth are now more permissive of use and far less likely to perceive marijuana use as harmful than in the past (Keyes et al., 2016; Sarvet et al., 2018b; Schmidt et al., 2016). Although the legal age to purchase marijuana is 21 in states currently enacting RML, recreational legalization may make marijuana more accessible to youth through purchases by older friends and family, expose youth to marijuana advertising, and enhance pro-social norms around marijuana use (Harpin et al., 2018; Lipperman-Kreda and Grube, 2018; Trangenstein et al., 2019). Consequently, RML may affect attitudes towards marijuana, as well as the age of initiation, prevalence, and frequency of use (D'Amico et al., 2018; Palamar et al., 2014), potentially resulting in higher levels of CUD among adolescents (Han et al., 2018).

Though recent reviews of research indicate that medical marijuana legalization (MML) is not associated with increasing adolescent marijuana use or CUD (Leung et al., 2018; Sarvet et al., 2018a), related research on RML is so far mixed, with some researchers finding no increase in adolescent marijuana use following RML (Anderson et al., 2019; Dilley et al., 2019), others finding evidence of increasing use in certain states (Cerda et al., 2017; Rusby et al., 2018), and still others finding a small increase in CUD (Cerda et al., 2019). These differing results may be due to the use of different data sets capturing marijuana use and dependence, differing methodological approaches, variation in

state contexts and marijuana regulatory frameworks, as well as simply a potential lag between the implementation of RML and its effects on adolescent marijuana use (Leung et al., 2018; Pacula et al., 2015).

If RML does increase CUD among youth, one potential consequence would be an increased need for treatment. To our knowledge, however, no studies thus far have examined changes in treatment admissions for marijuana use among youth following RML. Here, we investigate whether RML was associated with an increase in adolescent treatment admissions for marijuana use in Colorado and Washington, the first US states to enact RML, in late 2012, which thus provide the longest post-RML time period of all US states for analysis of youth treatment admissions trends. Using differences-in-differences analysis, this study compares treatment admissions trajectories in Colorado and Washington before and after RML enactment to states that did not enact RML.

2. Materials and methods

We use the 2008–2017 US Substance Abuse and Mental Health Services Administration's (SAMHSA) Treatment Episode Dataset-Admissions (TEDS-A) dataset to identify adolescent (age 12–17) substance use disorder (SUD) treatment admissions in the US where the primary substance used was marijuana or other THC preparations (n = 653,232). Consistent with previous research (Mennis et al., 2019), because the data do not represent individual clients but rather admissions, we restrict our sample to first time admissions to calculate the annual admissions rate of unique new clients (per 10,000 adolescent population) for each state. States other than Colorado and Washington which enacted RML during the study period (Alaska, California, Maine, Massachusetts, Nevada, and Oregon) are excluded from the analysis to ensure comparison to states where recreational marijuana use remained illegal. Wisconsin is excluded as it was missing from the TEDS-A dataset, and eight other states are missing a combined 22 observations (the 58 non-missing observations for those eight states were retained in the analysis), resulting in an analytical dataset of 408 annual admissions rate observations for 43 states over ten years.

We first investigate the general trend of treatment admissions over the study period by regressing admissions rate on year for all states in the study. As with previous research on the effects of RML (e.g. Aydelotte et al., 2017; Cerda et al., 2017), we employ difference-in-differences analysis to compare pre- and post-RML (beginning 2013) admissions rates in Colorado/Washington with states which did not enact RML during the 2008–2017 study period. To examine the difference-in-differences modeling assumption of parallel trends prior to 2013 we graph the admissions rates over time for Colorado/Washington and the non-RML states and test for moderation of the change in admissions rate by group prior to 2013 (Angrist and Pischke, 2009).

We run an unadjusted difference-in-differences model which includes a set of year dummy variables to account for the secular trend of treatment admissions, a dummy variable indicating Colorado/Washington, and the difference-in-differences variable indicating Colorado/Washington after RML enactment (beginning in 2013). We then run an adjusted model, which includes a set of state-year level covariates, including an index of socioeconomic disadvantage (Mennis et al., 2016, see Supplementary Materials for details), percent white (not Hispanic) population, and SUD treatment center availability (number of treatment centers per 10,000 adolescent population; SAMHSA National Survey of Substance Abuse Treatment Services [N-SSATS] data).

To test the sensitivity of our analytical results, we refit the difference-in-differences models using 2014 as the year of legalization (when RML was widely implemented in Colorado/Washington), excluding criminal justice referrals to treatment (to account for the potential effect of legalization on reduced criminal justice referrals to treatment; Chu, 2015), and for Colorado and Washington in separate models. We also investigate the sensitivity of the results to the choice of

counterfactuals by restricting the set of control states to: 1) states without RML or MML during the study period, 2) states with MML but without RML, 3) the seven non-RML states with rates of adolescent past-month marijuana use > 9% (which is similar to Colorado's and Washington's) just prior to RML in 2012, 4) the states that never enacted RML (either during or after the study period), and 5) the states that enacted RML after the study period. We also refit separate models that include all states enacting RML during the study period (not only Colorado and Washington), and enumerate the difference-in-differences coefficient for each year individually to investigate if RML affected admissions rates in any particular year (Angrist and Pischke, 2009; Wing et al., 2018). We refit an additional model that includes the proportion of criminal justice referrals as an independent variable, another model that adds the proportion of African American, Asian, and Hispanic admissions as independent variables, and another model that also adds the proportion of the total population covered by Medicaid and without health insurance as independent variables. All models are estimated using ordinary least squares regression and two-tailed significance tests at $p < 0.05$, conducted in SPSS Version 25 (IBM, Inc.). Normal probability plots of the regression residuals were used to ensure they do not deviate substantially from a normal distribution.

3. Results

Fig. 1 shows the mean admissions rate trajectories for Colorado/Washington and the non-RML states. The rate declines over time for all states, with the mean admissions rate falling by nearly half. The admissions rate is initially higher in Colorado/Washington at the beginning of the study period but declines more rapidly following RML as compared to the other states. As Fig. 1 suggests, there was no significant difference ($p < 0.05$) between groups in the slope of admissions rate prior to 2013, consistent with the parallel trends assumption of difference-in-differences analysis.

Table 1 shows the results for the model of the trend of admissions rates for all states (Model 1) as well as the unadjusted and adjusted difference-in-differences models (Models 2 and 3, respectively). Model 1 indicates that over all states in the analysis generally, the admissions rate declined significantly over time. Model 2 indicates that the decline in pre- versus post-2013 admissions rate was greater in Colorado/Washington as compared to the non-RML states (as shown in Fig. 1), though this difference was not statistically significant. Results were similar for the adjusted model, after controlling for socioeconomic disadvantage, percent white, and treatment availability. Greater socioeconomic disadvantage, higher percent white population, and lower treatment availability were significantly associated with lower admissions rates. Results from the sensitivity analyses did not differ in the direction or significance ($p < 0.05$) of the difference-in-differences
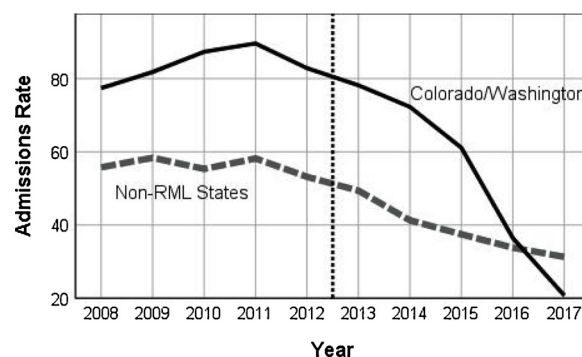

Fig. 1. Mean annual adolescent substance use disorder (SUD) treatment admissions rates (number of admissions per 10,000 resident adolescents) for Colorado/Washington (solid line) and non-RML states (dashed line), 2008-2017. Dashed vertical line indicates when RML was enacted in Colorado and Washington.

Table 1
Results of trend and unadjusted and adjusted difference-in-differences (DiD) models of rates of adolescent treatment admissions for marijuana use.

Independent Variable	Model 1[ab] (Trend)	Model 2[abc] (Unadjusted DiD)	Model 3[abc] (Adjusted DiD)
Year	−3.375***(-4.842, -1.907)		
CO/WA[d]		27.636*(0.320, 54.951)	−2.418(-24.797, 19.961)
DiD[e]		−12.492(-51.143, 26.158)	−7.671(-38.798, 23.456)
Disadvantage			−22.224***(-29.917, -14.532)
Percent White			−0.972***(-1.206, -0.739)
SUD Treatment Availability			3.268***(2.580, 3.955)

[a]Unstandardized coefficients are reported, 95 % confidence intervals in parentheses; [b] ***p < 0.005, *p < 0.05; [c] Model includes a set of year dummy variables; [d] 1 = Colorado/ Washington, 0 = non-RML states; [e] Differences-in-differences variable where 1 = Colorado/Washington during 2013–2017 and 0 = other states or years during.2008–2012.

coefficient (see Supplementary Materials), and did not substantively alter our conclusions.

4. Discussion

To our knowledge, this is the first study examining the effect of recreational legalization of marijuana in the US on adolescent treatment admissions for marijuana use. Our results indicate that RML in Colorado and Washington was not associated with an increase in treatment admissions. Rather, we observe a substantial decline in admissions rates across US states, with evidence suggesting a greater decline in Colorado/Washington following RML as compared to non-RML states, though this difference was not significant.

We speculate that the growing social acceptance and the decline in perceived risk of marijuana use nationally may have led to a marked decrease in youth treatment admissions in both Colorado/Washington and non-RML states, even if marijuana use remained stable or increased. We note that a decline in the rate of CUD among youth who regularly use marijuana would be consistent with observations among adults. Nationally CUD has remained relatively flat even as adult marijuana use has significantly increased (Compton et al., 2019), and the rate of marijuana dependence among adults (and adolescents) who are heavy marijuana users has declined (Davenport, 2018). De facto decriminalization of marijuana, which has occurred not only in RML states but in many other states where marijuana laws are simply enforced to a lesser degree, or penalties for small amounts of marijuana possession have been reduced to small fines, may also play a role in reducing the social stigma associated with marijuana use. A post-hoc analysis of the TEDS-A data indicates that criminal justice referrals to treatment for marijuana use among adolescents declined significantly (p < 0.05) over all states during the study period, and does not differ significantly between Colorado and Washington and the non-RML states.

While it is possible that the decreasing level of social stigma associated with marijuana use may make it more socially acceptable to seek treatment, it may also make users less likely to hide their use from friends and family, and may reduce the perception that their marijuana use negatively affects their social and work life (consistent with the observed decline in perceived risk), thus reducing the perception that heavy use warrants treatment. This effect may be even more pronounced in states legalizing recreational marijuana use, given that legalization is also a reflection of the greater degree of public acceptance of marijuana use. Legalization itself may also act to remove the social stigma of marijuana use associated with engaging in an illicit or criminal activity (Stolzenberg et al., 2016). It remains unclear, however, whether the decline in adolescent treatment admissions we observe is due to a decrease in the actual clinical need for treatment, a decrease in treatment seeking behavior due to a reduction in the perceived need for treatment, some combination, or other factors. However, if CUD remained stable following RML, or increased, as recent research indicates (Cerda et al., 2019), the dramatic decline in adolescent treatment admissions we observe in states enacting RML would suggest an increase

in unmet need for treatment, i.e. it may be the case that admissions rates are falling because an increasing proportion of adolescents with CUD are not entering treatment.

Potential limitations to the analysis include data quality issues associated with the TEDS-A dataset, such as variations in treatment admissions data collection practices and rates of treatment facility response among states and over time. It is also unknown how the missing TEDS-A observations impact the results. Nonetheless, the TEDS dataset represents the most comprehensive US addiction treatment admissions data available, which is why it has been used extensively to study national treatment patterns (Chu, 2015; Mennis et al., 2019; Pacula et al., 2015). We also acknowledge that certain treatment and facility characteristics have shifted over time. For example, according to N-SSATS data, the rate of outpatient (versus residential) treatment has increased slightly, the percentage of facilities receiving government funding has decreased, and the proportion of private for-profit (versus non-profit) facilities has increased over the study period. The prevalence of each of these characteristics may vary among states differently over time, potentially affecting the comparison of state-level admissions trends. Other unaccounted for state and time-varying socioeconomic, cultural, and health care factors, such as differences in rates of health insurance coverage and Medicaid expansion (which we investigated to some degree in the sensitivity analyses), may also affect treatment admissions, potentially inhibiting our ability to detect the effect of RML on admissions trends. We also acknowledge that RML may increase the likelihood of relapse and consequent re-admission into a treatment program, but we would not be able to detect this effect given our focus on adolescents entering treatment for the first time.

5. Conclusions

While we are encouraged that rates of new treatment admissions for marijuana use among adolescents exhibited a general decline in the states we examined, it is unclear whether this finding reflects trends in the prevalence of CUD or, rather, changes in treatment seeking behaviors due to changing perceptions of risk and public attitudes towards marijuana use. It may also simply be too early to detect the impact of RML on CUD and, hence, treatment admissions. Future research should investigate the causes of the dramatic decline in treatment admissions we observe in Colorado and Washington, examine the impact of RML on treatment admissions for young and older adults, and address the generalization of these findings to other states enacting RML, under different marijuana policy settings, and over longer time periods. Further research should also investigate the impact of legalization on youth access to various types of marijuana products, exposure to marijuana advertising, the social norms of marijuana use, and the potential health consequences for adolescents.

6. Contributors

Mennis and Stahler conceptualized the paper. Mennis performed the statistical analysis. Mennis and Stahler wrote the paper.

Role of funding sources

None declared.

Declaration of Competing Interest

None declared.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.drugalcdep.2020.107960.

References

Anderson, D.M., Hansen, B., Rees, D.I., Sabia, J.J., 2019. Association of marijuana laws with teen marijuana use: new estimates from the youth risk behavior surveys. JAMA Pediatr. 173 (9), 879–881.

Angrist, J.D., Pischke, J.-S., 2009. Mostly Harmless Econometrics: An Empiricist's Comparnion. Princeton University Press, Princeton, NJ.

Aydelotte, J.D., Brown, L.H., Luftman, K.M., Mardock, A.L., Teixeira, P.G.R., Coopwood, B., Brown, C.V.R., 2017. Crash fatality rates after recreational marijuana legalization in Washington and Colorado. Am. J. Public Health 107 (8), 1329–1332.

Cerda, M., Wall, M., Feng, T., Keyes, K.M., Sarvet, A., Schulenberg, J., O'Malley, P.M., Pacula, R.L., Galea, S., Hasin, D.S., 2017. Association of state recreational marijuana laws with adolescent marijuana use. JAMA Pediatr. 17 (12), 142–149.

Cerda, M., Mauro, C., Hamilton, A., Levy, N.S., Santaella-Tenorio, J., Hasin, D., Wall, M.M., Keyes, K.M., Martins, S.S., 2019. Association between recreational marijuana legalization in the United States and changes in marijuana use and cannabis use disorder from 2008 to 2016. JAMA Psychiat. https://doi.org/10.1001/jamapsychiatry.2019.3254.

Chu, Y.-W.L., 2015. Do medical marijuana laws increase hard-drug use? J. Law Econ. 58 (2), 481–517.

Compton, W.M., Han, B., Jones, C.M., Blanco, C., 2019. Cannabis use disorders among adults in the United States during a time of increasing use of cannabis. Drug Alcohol Depen. https://doi.org/10.1016/j.drugalcdep.2019.05.008.

D'Amico, E.J., Rodriguez, A., Tucker, J.S., Pedersen, E.R., Shih, R.A., 2018. Planting the seed for marijuana use: changes in exposure to medical marijuana advertising and subsequent adolescent marijuana use, cognitions, and consequences over seven years. Drug Alcohol Depen 188, 385–391.

Davenport, S., 2018. Falling rates of marijuana dependence among heavy users. Drug Alcohol Depen 101, 52–55.

Dilley, J.A., Richardson, S.M., Kilmer, B., Pacula, R.L., Segawa, M.B., Cerda, M., 2019. Prevalence of cannabis use in youths after legalization in Washington State. JAMA Pediatr. 173 (2), 192–193.

Hall, W., Lynskey, M., 2016. Evaluating the public health impacts of legalizing recreational cannabis use in the United States. Addiction. 111, 1764–1773.

Han, B., Compton, W.M., Blanco, C., Jones, C.M., 2018. Time since first cannabis use and 12-month prevalence of cannabis use disorder among youth and emerging adults in the United States. Addiction 114, 698–707.

Harpin, S.B., Brooks-Russell, A., Ma, M., James, K.A., Levinson, A.H., 2018. Adolescent marijuana use and perceived ease of access before and after recreational marijuana implementation in Colorado. Subst. Use Misuse 53, 451–456.

Keyes, K.M., Wall, M., Cerdá, M., Schulenberg, J., O'Malley, P.M., Galea, S., Feng, T., Hasin, D.S., 2016. How does state marijuana policy affect US youth? Medical marijuana laws, marijuana use and perceived harmfulness: 1991-2014. Addiction 111 (12), 2187–2195.

Kosty, D.B., Seeley, J.R., Farmer, R.F., Stevens, J.J., Lewisohn, P.M., 2016. Trajectories of cannabis use disorder: risk factors, clinical characteristics and outcomes. Addiction 112, 279–287.

Leung, J., Chu, C.Y.V., Stjepanović, D., Hall, W., 2018. Has the legalisation of medical and recreational cannabis use in the USA affected the prevalence of cannabis use and cannabis use disorders? Curr. Addict. Rep. 5 (4), 403–417.

Lipperman-Kreda, S., Grube, J.W., 2018. Impacts of marijuana commercialization on adolescents' marijuana beliefs, use, and co-use with other substances. J. Adolesc. Health 63, 5–6 108.

Mennis, J., Mason, M., Light, J., Rusby, J., Westling, E., Way, T., Zaharakis, N., Flay, B., 2016. Does substance use moderate the association of neighborhood disadvantage with perceived stress and safety in the activity spaces of urban youth? Drug Alcohol Depen 165, 288–292.

Mennis, J., Stahler, G.J., El Magd, S.A., Baron, D.A., 2019. How long does it take to complete outpatient substance use disorder treatment? Disparities among Blacks, Hispanics, and Whites in the US. Addict. Behav. 93, 158–165.

Miech, R.A., Johnston, L.D., O'Malley, P.M., Bachman, J.G., Schulenberg, J.E., Patrick, M.E., 2019. Monitoring the Future National Survey Results on Drug Use, 1975–2018: Volume I, Secondary School Students. Available at. Ann Arbor: Institute for Social Research, University of Michigan. http://monitoringthefuture.org/pubs.html#monographs.

Pacula, R.L., Powell, D., Heaton, P., Sevigny, E.L., 2015. Assessing the effects of medical marijuana laws on marijuana use: the devil is in the details. J. Policy Anal. Manage. 34 (1), 7–31.

Palamar, J.J., Ompad, D.C., Petkova, E., 2014. Correlates of intentions to use cannabis among US high school seniors in the case of cannabis legalization. Int. J. Drug Policy 25, 424–435.

Rusby, J.C., Westling, E., Crowley, R., Light, J.M., 2018. Legalization of recreational marijuana and community sales policy in Oregon: impact on adolescent willingness and intent to use, parent use, and adolescent use. Psychol. Addict. Behav. 32 (1), 84–92.

Sarvet, A.L., Wall, M.M., Fink, D.S., Greene, E., Le, A., Boustead, A.E., Pacula, R.L., Keyes, K.M., Cerda, M., Galea, S., Hasin, D.S., 2018a. Medical marijuana laws and adolescent marijuana use in the United States: a systematic review. Addiction 113, 1003–1016.

Sarvet, A.L., Wall, M.M., Keyes, K.M., Cerda, M., Schulenberg, J.E., O'Malley, P.M., Johnston, L.D., Hasin, D.S., 2018b. Recent rapid decrease in adolescent's perception that marijuana is harmful, but not concurrent increase in use. Drug Alcohol Depen 186, 68–74.

Schmidt, L.A., Jacobs, L.M., Spetz, J., 2016. Young people's more permissive views about marijuana: Local impact of state laws or national trend? Am. J. Public Health 106 (8), 1498–1503.

Stolzenberg, L., D'Alessio, S.J., Dariano, D., 2016. The effect of medical cannabis laws on juvenile cannabis use. Int. J. Drug Policy 27, 82–88.

Trangenstein, P.M., Whitehill, J.M., Jenkins, M.C., Jernigan, D.H., Moreno, M.A., 2019. Active cannabis marketing and adolescent past-year cannabis use. Drug Alcohol Depen 204 (1), 1075.

Volkow, N.D., Baler, R.D., Compton, W.M., Weiss, S.R., 2014. Adverse health effects of marijuana use. N. Engl. J. Med. 370 (23), 2219–2227.

Wing, C., Simon, K., Bello-Gomez, R.A., 2018. Designing difference in differences studies: best practices for public health policy research. Annu. Rev. Public Health 39, 453–469.